# Study of Micro/Nano Scale EHD-Driven Flow Distribution Control and Heat Transfer Enhancement for Thermal Control Systems

Completed Technology Project (2014 - 2018)

## Project Introduction

Innovative aerospace technologies constantly redefine the limits for what is possible, always pushing the envelope of every performance parameter and creating smaller, more efficient, more powerful instruments. However, such advances in technology usually require higher heat generation and greater thermal control needs. Novel thermal control systems built to handle these thermal challenges must be small, light-weight and able to maintain long-term operation in variable gravity under harsh conditions. Electrohydrodynamic (EHD) conduction pumps control the flow of dielectric fluids via applied electric fields. These pumps have simple, flexible designs, no moving parts and good heat transfer capabilities. These pumps have been proven to be effective for long periods of time, in microgravity conditions, have flow distribution capabilities and perform better at smaller scales. The scientific literature lacks information on the behavior of the EHD conduction mechanism in nano-scale, where the simplifying assumptions of the mathematical models for larger scales no longer apply. The literature also lacks information about this technology's capability to distribute multi-phase flow in amsller scales, where two-phase flow in multi-channels is difficult to control in a stable fashion. Lastly, although EHD conduction pumps have been tested for prolonged use, the technology's ability to maintain control of the flow under disruptive operational perturbations has not been explored. This project proposes a research plan for obtaining a fundamental understanding of the EHD conduction phenomenon as it pertains to small-scale, distributive flow systems under realistic perturbations, and to utilize this understanding to optimize the heat transfer performance of small-scale EHD conduction pumps. For this purpose, the mathematical models currently used for EHD conduction will be revisited and modified for smaller scales and for periodic and random perturbations. These models will be numerically solved and optimized for heat transfer performance. Experimental setups at various scales will be designed, built and tested in variable gravity conditions to verify the numerical results and ensure that the technology can withstand its expected working conditions when integrated with future aerospace systems. Since the technology has already proven to be space worthy, this further optimization promises to make EHD conduction pumps extremely useful for aerospace applications ranging from microsatellite projects such as the CubeSat to crew quarter temperature management for future manned missions. Its reliability over long periods of time and minute power consumption make it ideal for long-term missions as well, making the EHD conduction offering very well rounded for future aerospace applications.

## Anticipated Benefits

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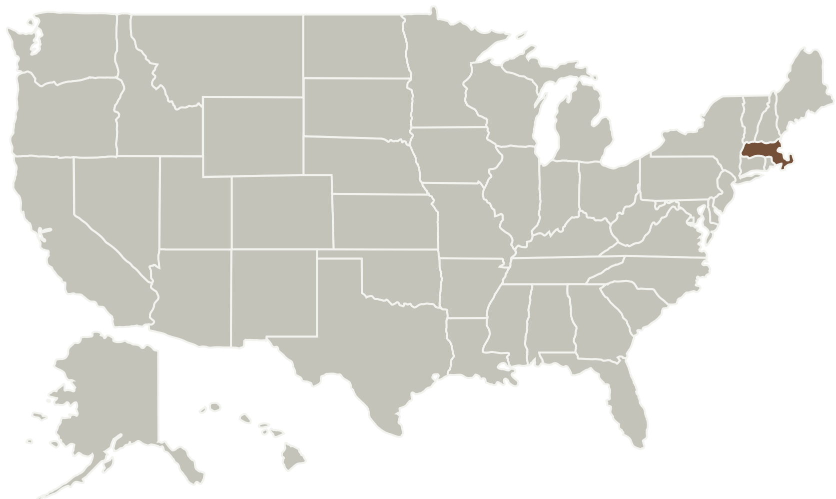
## Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| Worcester Polytechnic Institute | Lead Organization | Academia | Worcester, Massachusetts |

| Primary U.S. Work Locations |
|---|
| Massachusetts |

### Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

Worcester Polytechnic Institute

**Responsible Program:**

Space Technology Research Grants

## Project Management

**Program Director:**

Claudia M Meyer

**Program Manager:**

Hung D Nguyen

**Principal Investigator:**

Jamal Yagoobi

**Co-Investigator:**

Michal Talmor

## Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**

1 2 3 4 5 6 7 8 9

Applied Research | Development | Demo & Test

## Technology Areas

**Primary:**

- TX08 Sensors and Instruments
  - └ TX08.3 In-Situ Instruments and Sensors
    - └ TX08.3.3 Sample Handling

## Target Destinations

Earth, The Moon, Mars